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REVIEW.

BURNHAM'S GENERAL CATALOGUE OF DOUBLE STARS.[1]

By Eric Doolittle.

For several years all astronomers interested in double-star observation have been anxiously awaiting the appearance of this great work. It has long been known that Mr. **Burnham** had at enormous labor formed a complete record in manuscript of practically every double-star measure ever made, and that he had kept this continually posted to date by the addition of each new discovery and measure as it was published. His own account of the need he felt for such a work when he first began his long list of discoveries, and of how he proceeded to obtain it, is found in the "Introduction to the General Catalogue of 1290 Burnham Stars." When the last sentence of this account is duly weighed I think it will be admitted that there are indeed few who would have had the courage to undertake so extensive a labor, and still fewer who, having begun it, would have carried it to a successful conclusion.

> "The want of a single catalogue of all double stars visible in the northern hemisphere was very manifest soon after the commencement of the observations with the 6-inch refractor. Many pairs were picked up on every good night which it was desirable to identify with as little loss of time as possible. If wanting in Struve, Herschel, and other of the old catalogues, they might still be known pairs, and it was unsafe to assume that they had not been before observed without a careful examination of minor lists, catalogues, and observations of various kinds scattered throughout a large number of volumes issued by observatories and societies, periodicals, handbooks, and monographs printed in the last hundred years. I was therefore compelled, in the interest of my own work, to bring this material together and arrange all the pairs in order of right ascension in a general catalogue. In this way I made a manuscript catalogue of every known double star within 121° of the north pole, giving the details of measures, magnitudes, star-catalogue references, etc. With this at hand, it was but a moment's work at the telescope to identify any known object, and to decide at once whether or not an object thus found was really a new pair. This catalogue subsequently passed into a second manuscript edition. This

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[1] A General Catalogue of Double Stars within 121° of the North Pole, by S. W. **Burnham**. 2 vols. 4to. pp. lxiii + 1086. The Carnegie Institution of Washington.

served the purpose for a good many years, but the time came when the manuscript became too crowded by the interlineation of stars discovered by myself and other observers, and by the addition of a great number of references to measures and observations, and then I undertook the preparation of a third manuscript edition, which was arranged in the proper form for printing, with ample space for new stars and new observations, and giving a brief statement or discussion of the character of each pair of any general interest. This catalogue is substantially bound in twelve volumes. Very few will fully appreciate the enormous amount of hard work which has been necessarily expended in the preparation of such a work. Whether it will ever assume other than the present manuscript form remains to be seen. It should be remarked in this connection that, with the exception of the four years 1888-1892, all of this astronomical work, with the telescope and otherwise, has been done when eight or more hours of at least six days in the week were more or less occupied with other and very different affairs of life."

This manuscript catalogue was the only work of its kind in existence. Since its formation nearly all double-star observers have been indebted to Mr. BURNHAM for his willingness not only to compare their discoveries and measures with it, but even to copy out for them long lists of stars on which measures are needed. It has long been felt by many that in no direction could money be more profitably spent for the advancement of astronomy than in securing the publication of this catalogue. This has now been accomplished; the work appears as Publication No. 5 of the Carnegie Institution of Washington.

The great value of the catalogue lies not so much in its use to the searcher for new pairs—though to him it is almost indispensable—but more especially in its help to the measurer of known pairs. It should wonderfully increase the efficiency of all double-star work in this direction for many years to come. Without it the preparation of an observing-list has been a long and unsatisfactory undertaking. The observer began by forming a preliminary list of perhaps eight hundred or a thousand stars, which on account of their neglect or motion seemed to require remeasurement. The next step was to go over all the scattered measures in the books and journals which were accessible to him and to strike off one after another each pair which proved to have been adequately measured elsewhere. From the preliminary list he was fortunate if three hundred or four hundred stars remained to constitute his final working list, and unless the libraries to which he had access were unusually complete he could not even be certain that there were not many of these on which his labor of observing was wasted. When it was a question of rejecting or observing isolated pairs met with after his observing-list was made up, and which seemed of interest for any of several reasons, the matter was still more uncertain. It would always be easier to remeasure such pairs than to hunt through all the prior records of observations, but to do this was to risk wasting a part of the limited number of clear hours available for work. Now that the catalogue is published, all of this labor requires but a few hours, and the observer can easily make certain that the stars which he selects are those most urgently in need of measurement.

The catalogue in printed form comprises two quarto volumes of more than one thousand pages, but, in spite of its size, it is a marvel of compactness. The introduction, which might easily have been expanded into a hundred pages or more, is condensed into very slightly more than eight; the index to seven thousand pairs discovered by the more prominent modern observers is reduced by an ingenious scheme of tabulation to but ten pages, and the seven tables giving the classification when possible of the more than thirteen thousand pairs, as to the character of their motion, requires but eight pages more. This difficult principle of securing the utmost conciseness has been followed throughout, yet it does not appear that a single fact of importance has been omitted.

The first volume contains descriptions of the 13,665 double stars which have so far been discovered within 121° of the north pole. Through an appendix even the most recent discoveries of Hussey and Aitken are included, so that every double star whose discovery was published not later than 1906 will be found in this work. The southern limit of —31° which is adopted for the catalogue includes all of the stars which can be well observed at the northern observatories. In Mr. Burnham's opinion it will probably not be until the end of the present century that measures and discoveries of pairs further south will have so accumulated as to make a similar catalogue of the southern heavens desirable.

The vexed question, Which of the pairs recorded by various astronomers as double shall be included in the catalogue? is here solved by retaining all of them. Mr. Burnham writes on this subject:—

"The question of drawing some kind of arbitrary line between what might be presumed to be physical systems, and those which it was practically certain could not belong to that class, was considered at an early day in the preparation of this work. It was soon apparent, from a practical application of the principles which were supposed to govern a judicious separation of the material into these two classes, that it could not be successfully done. A too liberal application of the rule would reject a comparatively small number and so accomplish but little in reducing the size of the catalogue; while, on the other hand, the rigid enforcement would necessarily exclude many stars which are of some interest at least, in consequence of changes already shown from proper motion. Then again, the names of the great astronomers attached to these stars entitle them to a place in the first catalogue of double stars, independent of any consideration of the stars themselves. I have therefore included them all, and as far as possible remeasured the large number of neglected pairs of the old observers for this work."

It seems to us that this is a most fortunate decision. It is to be noticed that, with very few exceptions, it is only the bright or very close doubles which have thus far been observed, and that the orbits of such pairs only are known to us. How many faint and comparatively wide pairs there are which are true binaries we cannot conjecture. There is at least one such example (KRUEGER 60), of which the components are of the 9.0 and 12.0 magnitude and 3″.5 apart, whose period will almost certainly not exceed two hundred years. If two thousand or three thousand such pairs are catalogued and a considerable number of these afterward found to be binary, this will go far toward solving the general question of the comparative masses and distances of the faint and bright stars.

Mr. BURNHAM finds that 585 pairs have a common proper motion. Many of these are faint and widely separated, and yet it is very probable that they are physically connected, the periods being reckoned in thousands of years. Perhaps the two best-known examples are μ^1 *Herculis* and 40 *Eridani,* the former being separated by 30″ and the latter by 80″. That these great distances could have been attained through tidal action seems hardly possible; we cannot even conjecture what the form of their relative paths is likely to be, but to secure and record at least one good measure on every such pair is a debt which the astronomers of to-day owe to posterity. Perhaps the most liberal scheme for the exclusion of double stars is that employed by INNES in his Reference Catalogue of Southern Double Stars. Yet, were this rigorously applied, not only would the distant companions of μ *Herculis* and 40 *Eridani* be rejected as of no interest, but these two attendants, each of which is a faint binary of comparatively short period, would both be excluded also.

The first volume contains the position of each star reduced to 1880.0, and the date, position-angle, distance, and magnitudes at the time of the first measure. For fully ninety per cent the identification is given; many of those in which this is omitted are too faint to be found in any of the catalogues.

The second volume gives a sufficient number of selected measures to show the character of motion in each pair, and in addition to these the complete references in each case to every measure which has ever been made on it and to all important notes and papers relating to it. The latest values of the proper motions of the principal stars are also included. Mr. BURNHAM is decidedly of the opinion that when many good measures are available the more uncertain ones should be unhesitatingly rejected. He says on this point:—

> "For obvious reasons only the best measures by the best observers are selected as a rule, and those made on a single night have been generally rejected, except when there was nothing else in point of time to take their places. It must be clear to every one that the omission of all indifferent and superfluous observations necessarily adds to the value and usefulness of this work. The author has not been handicapped or limited in any way as to space to be used; and in the citation of observations and in the comments relating thereto he has omitted nothing that in his judgment would be worth giving. It goes without saying that a large number of the published measures of double stars should be rejected in any investigation or discussion as to the relative motion of the components. There need be no difficulty or hesitation in deciding as to the proper material to be used. If all the observations—good, bad, and indifferent—are employed in the computation of an orbit, it is certain that the value of the result will be correspondingly impaired, and no method of treating the doubtful material will prevent this."

Beside this enormous labor of compilation there is a condensed but most thorough discussion of each pair in which there has been change. Hundreds of new and carefully constructed diagrams are given in this connection. Certainly no work could be more valuable or more authoritative than this. It is needless to say that Mr. BURNHAM never attempts to get out of the measures more than the material will certainly show. Even in the introduction space is spared to emphasize the inutility of attempting to compute orbits when the measures are wholly insufficient for this purpose, and in Part II not a line is given up to speculation or to misleading computations of future motion when this must at present be very uncertain. For several of the pairs in which a whole revolution has been completed the period only is stated, and for others for which orbits have been computed it is not even asserted that the motion is orbital at all. As might be expected, Mr. BURNHAM is equally conservative in regard to the presence of dark bodies which have been supposed to disturb the motion of the bright stars. That in *ζ Herculis* is not even mentioned, while the indications of a long suspected third body in F 70 *Ophiuchi* are believed to be equally well explained by the ordinary errors of observation.

When this great mass of material is examined Mr. BURNHAM finds the following general results: There are eighty-eight pairs for which orbits have been computed, of which, however, only thirty-four can be regarded as of any value. There are ninety-four systems which are certainly binary. There are 112 pairs which are probably binary, and thirty-eight pairs in which the two stars have different proper motions, as in the well-known system 61 *Cygni*. There are 585 pairs having common proper motion and 337 in which, from meridian-circle observations, proper motion has been observed in the principal star. Thus of the entire list of 13,665 stars there are but 879 for which a physical connection can at this time be inferred.

No discussion is attempted of the distribution of these stars on the sky, nor is any attempt made to theorize on the construction and extent of the stellar universe. While the discoveries and measures are still both so incomplete, it is the belief that all such generalizations are idle and useless. Mr. BURNHAM strongly emphasizes the fact that what is wanted now for the advancement of double-star astronomy is not theories and speculations, or even extensive computations, but only careful, prolonged, and systematic observations with the telescope. It cannot be doubted that a great impetus will be given to observations in this important branch of astronomy, and that their value will be exceedingly enhanced by the publication of this monumental work.

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